Fiscal Year:	FY 2018	**Task Last Updated:**	FY 06/01/2018
PI Name:	Strangman, Gary E Ph.D.		
Project Title:	Quantifying and Predicting Operationally-Relevant Performance in a Long-Duration Spaceflight Analog		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Behavior and performance		
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **HFBP**:Human Factors & Behavioral Performance (IRP Rev H)		
Human Research Program Risks:	(1) **BMed**:Risk of Adverse Cognitive or Behavioral Conditions and Psychiatric Disorders (2) **Sleep**:Risk of Performance Decrements and Adverse Health Outcomes Resulting from Sleep Loss, Circadian Desynchronization, and Work Overload		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
PI Email:	strang@nmr.mgh.harvard.edu	**Fax:**	FY
PI Organization Type:	NON-PROFIT	**Phone:**	617-724-0662
Organization Name:	Massachusetts General Hospital		
PI Address 1:	Department of Psychiatry		
PI Address 2:	149 13th Street, Suite 2651		
PI Web Page:			
City:	Charlestown	**State:**	MA
Zip Code:	02129-2020	**Congressional District:**	7
Comments:			
Project Type:	Ground	**Solicitation / Funding Source:**	2015-16 HERO NNJ15ZSA001N-ILSRA. Appendix F: International Life Sciences Research Announcement
Start Date:	08/01/2016	**End Date:**	01/31/2020
No. of Post Docs:	2	**No. of PhD Degrees:**	0
No. of PhD Candidates:	0	**No. of Master' Degrees:**	0
No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NASA JSC
Contact Monitor:	Williams, Thomas	**Contact Phone:**	281-483-8773
Contact Email:	thomas.j.will1@nasa.gov		
Flight Program:			
Flight Assignment:	NOTE: Extended to 1/31/2020 per K. Ohnesorge/HRP JSC (Ed., 5/24/18) NOTE: Element change to Human Factors & Behavioral Performance; previously Behavioral Health & Performance (Ed., 1/18/17)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Zhang, Quan Ph.D. (Massachusetts General Hospital)		
Grant/Contract No.:	NNX16AO30G		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	Exploration spaceflight missions will expose crewmembers to many risks that could affect their performance and mission success. Minimizing such risks will require identifying and validating objective indicators of behavioral health and performance (BMed2 Gap), understanding the contribution of sleep loss on individual behavioral health (Sleep2 Gap), and identifying countermeasures that can reduce these risks (BMed1, BMed6, and Sleep9 Gaps). Currently the Robotic On-Board Trainer (ROBoT) is used operationally by astronauts both on the ground and on the International Space Station (ISS) to practice Canada Arm activities. Our group is helping adapt ROBoT for research use and for quantitative performance assessment. In addition, our group is developing and testing NINscan-SE: a multi-use system for measuring brain and physiological function. Both ROBoT and NINscan-SE are being characterized and validated in our laboratory, and will undergo analog feasibility testing during the Human Exploration Research Analog (HERA) C4 and C5 campaigns. In this project, we will deploy both systems to: Aim 1: Characterize operational task performance changes during 45-day HERA missions, including the roles of time-in-mission, workload, sleep debt, and operational emergencies. Aim 2: Characterize brain and systemic physiology changes during 45-day HERA missions, including the roles of time-in-mission, workload, sleep debt, and operational emergencies. Aim 3: Identify physiological or behavioral variables that predict operational performance. Aim 4: Quantify the influence of behavioral health countermeasures on both operational performance and (neuro)physiological measures. To achieve these aims, we will recruit up to 32 crewmembers from eight 45-day missions in the HERA facility during Campaigns 4 and 5, plus up to 32 control subjects. HERA and control participants will all perform ROBoT tasks plus undergo physiological monitoring 2x/week, on matching schedules, thus enabling us to differentiate changes in operational performance due to practice over time from any changes due to HERA sequestration. In addition, two “unexpected operational emergency” events will be introduced in the first and last weeks of each HERA mission. These will consist of an acute need to capture a wayward satellite traveling near the limits of Canada Arm capabilities. We will also work with the Behavioral Health and Performance (BHP) Element and other HERA investigators to coordinate ROBoT and physiological data collection before, during, and after one or more countermeasure (CM) deployments during the HERA missions. CM(s) may include a lighting intervention, a Virtual Space Station-based behavioral intervention, diet, exercise or some other intervention. The experimental design will depend on the nature of the CM. We will test hypotheses that the CM(s) generate detectable changes in ROBoT performance and rest/task (neuro)physiology recordings. We will also compare ROBoT performance to the standardized Behavioral Core Measures (BCM), if possible. The knowledge-deliverables of this project will describe: (i) changes in operationally-relevant (ROBoT) performance during the HERA mission in a well-controlled analog study of substantial size; (ii) changes in cerebral and systemic physiology associated with HERA mission parameters as well as operational performance; (iii) identification of potential predictors of future ROBoT performance; and (iv) the influence of the investigated countermeasure(s) on operational performance and physiology.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	The ROBoT system—and the HERA isolation protocol—are quite specific to NASA spaceflight operations and hence have relatively few direct Earth applications. However, the ROBoT spacecraft-capture simulations represent a highly skilled, complex operational performance task. It could thus be used as a comparison task in concert with detailed cognitive testing to help dissect the cognitive components complex tasks as well as the influence of other physiological stressors (e.g., sleep deprivation, alcohol consumption, medical radiation) on the performance of such tasks. Use of different complex tasks with the same approach could be useful in assessing and predicting performance in a wide range of other operational environments (diving, pilots, military, surgeons, etc.). Regarding NINscan-SE, no current NIRS, EEG, or polysomnography device has both the portability and the multi-use features of the system we will be deploying. This system could thus have substantial novel Earth applications. Hospital monitoring applications could include long-duration, non-invasive brain monitoring in the NeuroICU following stroke or traumatic injury, for which no similar technology exists. Real-time, in-office brain activation assessment could also be supported, for assessment of psychiatric states, for monitoring the neural effects of cardiovascular or psychoactive drugs or other therapies, or for brain monitoring during rehabilitation. Mobile monitoring could perhaps have an even larger impact outside the hospital setting. A wearable monitor would enable ambulatory syncope monitoring, or multi-parameter ambulatory epilepsy monitoring. If deployed in emergency settings, NINscan-SE could potentially be used to detect cerebral or abdominal hemorrhage, ischemia, and/or cortical spreading depression by first responders. Home monitoring uses include various sleep disorders, as well as various commercial possibilities.
	The goal of this project is to assess operationally-relevant behavioral performance over 45-day isolation and confinement periods in the Human Exploration Research Analog (HERA), as well as associated neurophysiological status during this period. Operational performance is being evaluated using the ROBoT-r task—an operationally used track-and-capture task for grappling incoming resupply vehicles using Canadarm2. This task was modified for research use in the separate Behavioral Core Measures project. Neurophysiological assessments include resting-state connectivity and functional brain activation during the ROBoT-r task trials using our near-infrared spectroscopy and imaging (NIRS/NIRI) based NINscan devices. In Year 2 of this project, the following tasks have been completed. ROBoT-r v6.3 Software: While ROBoT-r v6.2 remains deployed in HERA for Campaign 4, additional modifications have been underway for the software. This included an important upgrade that prevents any accidental bumping of the hand controllers between trials from causing a trial abort, as well as a few minor modifications to the feedback displays provided after each trial. These display modifications were made based on discussions with ROBoT-r trainers to ensure consistency of feedback between research and operations use of the ROBoT-r task. HERA Data Collection: At the time of the first annual report, HERA Campaign 4 Mission 1 was complete and preparations for C4M2 were underway. C4M2 was completed through mission day (MD) 22, at which point Hurricane

Task Progress:	Harvey required evacuation of the facility, thus aborting the mission. C4M3 was completed without incident, as was C4M4. Currently, C4M5 is underway. In each case, Dr. Ivkovic traveled to Houston to confirm appropriate setup of the system and conducted all crew familiarization (with both ROBoT-r and NINscan-SE), training, and all baseline data collection. ROBoT-r and NINscan-SE data was also validated (to confirm the appropriate data was being collected) prior to hatch-closing for each mission. Data was collected nominally during each mission. We obtained 97.7% of ROBoT-r data expected from Missions 1-4, and 96.8% of the NINscan physiological data. HERA Data Analysis: Analyses to date have been limited to quality control and very preliminary assessments. ROBoT-r data is demonstrating learning curves consistent with expectations based on HERA C3 testing. NINscan data is also showing basic phenomena consistent with expectations including inter-hemispheric functional connectivity at rest, brain activation associated with engagement in the ROBoT-r task, and suppression of low-frequency EEG waveforms associated with task engagement. Analysis procedures are being finalized to address our specific aims and an interim analysis will be conducted when all data from Campaign 4 is available. Controls: We completed running controls for our HERA C3 mission and then swapped hardware and upgraded software at Massachusetts General Hospital (MGH) to match the hardware/software versions in HERA C4. We are now recruiting controls for HERA C4, seeking to match HERA subjects as closely as possible. These subjects will continue to be run through much of year 3 of the project. Dissemination: The results to date of ROBoT-r data collection were presented at the Human Research Program (HRP) Investigator Workshop (IWS) conference in Galveston, TX in late January 2018. In the remaining 2 months of grant year 2 we anticipate completing the following activities. HERA C4M5 Completion: Mission 5 is the replacement for the aborted Mission 2. This mission is scheduled hatch opening on 6/15/2018, followed by a 1-week period of post-mission data collection. At that point we will have completed all of Campaign 4 subjects and will be able to pool data across C4 subjects to characterize their performance over the course of the 45-day missions. Research on this project will continue in Campaign 5, following a planned 6-month delay in startup, and our main research questions will be addressed once we complete data collection for all C4 control subjects.
Bibliography Type:	Description: (Last Updated: 02/05/2025)